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**HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII**

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**PROPAGATION OF PLANTS BY CUTTINGS
IN HAWAII**

BY

Senior Horticulturist

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INTRODUCTION

The rooting of cuttings is one of the most important methods of plant propagation in Hawaii. The major agricultural crop plants of the Territory, sugar-cane and pineapple, are propagated vegetatively by cuttings. Among other useful plants, which are grown in home gardens and to some extent as commercial crops, by means of cuttings, are the banana, taro, sweet potato, white potato, ginger, fig, grape, seedless breadfruit, date, and mulberry; also several kinds of forage plants and numerous perennial ornamentals. In horticultural work, the term "cutting" has reference to the detached part of a plant used in vegetative propagation. To quote E. S. Goff, "A cutting is a detached part of a plant intended to be placed in the soil or some other medium for the purpose of developing roots." (4)¹

There are several advantages in propagating plants by cuttings. Many kinds of plants rarely seed, and when they do the seeds germinate with more or less difficulty. Like other plants produced vegetatively, cutting plants retain their specific and varietal characters, and possess certain life habits. They continue the span of life of the original parent seedlings according to the natural laws governing their kinds. Propagation by cuttings is a rapid means of increasing the number of plants of a given variety, and the use of cuttings in crop production saves time, for plants so propagated usually come into productiveness much earlier than do seedlings.

The rooting of plants by means of cuttings is discussed

¹ Italic numbers in parentheses refer to Literature Cited, page 35.

briefly and in a general way in many horticultural publications. Very few books and bulletins describe the rooting of cuttings of any considerable number of kinds of plants, particularly those that may be propagated in Hawaii. Since the establishment of the Hawaii Experiment Station in 1901, more than 6,000 accessions of plants have been recorded in the Horticultural Division. Many of these introductions are from other parts of the world, and their requirements often differ; consequently, the investigation of vegetative propagation has been of considerable importance. The general principles for rooting cuttings, as given in general horticultural publications, are herewith supplemented with certain special methods which have been found to be desirable under Hawaiian conditions.

CHIEF ESSENTIALS AND KINDS OF CUTTINGS

The essentials for rooting cuttings are the same as those for germinating seeds, warmth, moisture, and oxygen. These essentials bring about a chemical change in the stored plant food of the tissues of the cuttings such that there results a development of roots below, followed by shoots having leaves above.

The term cutting, when unrestricted, is given to parts of the stem. A leaf or part of a leaf is called a leaf-cutting, and in like manner, a piece of a root may be called a root-cutting.

Stem-cuttings are classified, according to the nature of growth, as soft-wood cuttings and hard-wood cuttings. However, in the tropical conditions of Hawaii, there are numerous plants which may be rooted by cuttings having most any condition of stem varying between the two recognized limits. A few such examples are hibiscus, ti, panax, acalypha, and barleria. Aside from providing sufficient moisture, these cuttings usually require but little attention. Many plants growing in tropical and semi-tropical climates often possess one or more distinct growing periods or prolonged growing periods in the course of a year, which makes cutting material comparatively easy to obtain. Climate also exerts a marked influence upon the tendency of plants to develop from cuttings. A warm, moist atmosphere is very favorable to cutting propagation.

Leaf-cuttings are often employed in propagating many kinds of fleshy-leaved plants. The tissues of certain parts of the leaf,

such as the leaf-stalk, midrib, and margin of the blade, are adapted to the development of adventitious buds which will form new plants when placed in certain favorable conditions. Examples of such plants are *Begonia rex*, *Bryophyllum*, *Gesneria*, *Gloxinia*, *Saintpaulia*, and *Peperomia*.

Root-cuttings are extensively used as a means of vegetative propagation. Many plants naturally sprout from roots, while others do not respond with sprouts from below ground unless some immediate portion of the root has been wounded. A few common examples of plants which root freely, or may be caused to root from their true roots, are guava, lime, orange, mulberry, seedless breadfruit, horse-radish, and certain species of *Rubus*.

In the growth of such plants as the banana, ginger, and canna, the stem remains below ground and from the nodes are sent up off-shoots, sometimes called suckers, which eventually separate naturally from the parent plant or may be separated as cuttings. Other plants, such as species of mint, have both upright stems above ground and creeping underground stems called rhizomes, the latter of which propagate easily when made into cuttings.

The common white potato, a fleshy rootstock or underground stem commonly called a tuber, contains a number of buds, sometimes called eyes, each of which will develop a plant. Sweet potatoes are thickened roots, the skin of which is adapted to the production of adventitious buds suitable for propagation. (Fig. 1.)

Propagating medium. Experiment and long practice have indicated that the best rooting medium for most plants is clean sand. This holds the cuttings in place and permits a liberal application of the essentials. Most cutting tissues contain enough plant food to start root growth. When they get the recognized essentials, warmth, moisture, and oxygen, growth begins and roots are formed. They must then find plant food from some outside source to supply the growing top.

In Hawaii, there are two kinds of beach sand suitable for use in propagation activities, "white coral" and "black volcanic." A sharper-grained volcanic sand of somewhat different formation is obtainable in some parts of the Territory. It is found in extensive deposits, the material having been discharged from explosive craters in past ages, and the particles not worn smooth by a movement of water. In different parts of a deposit, the par-

ticles are of various sizes so that it is possible to get either a coarse or fine propagating medium. If greater uniformity is necessary, this may be obtained by screening.

Sand, for propagating purposes, should be exposed to the air and sun for a few weeks and then thoroughly washed before being used. It should be relatively free of all decaying organic matter that may transmit fungus diseases. All chemical substances soluble in water should be washed away, for they are detrimental to the early stages of root formation. If kept clean, propagating sand may be used repeatedly.



FIGURE 1.—A, Cutting of Sea-grape,—the basal cut is made through the horizontal woody partition of the node to avoid development of pith fungus; B, Grape cutting showing sloping cut at basal end; C, Citrus cutting, rooted; D, Root-cutting of the seedless breadfruit showing its use in propagating the plant; E, Single-node cutting tied to a plant label to hold it at proper depth in the soil; F, Herby cutting with basal cut made at the internode.

GENERAL METHOD OF CUTTING PROPAGATION

The general or most common method of rooting cuttings is employed in the propagation of a large number of plants and trees in the tropics. In Hawaii, most cuttings are rooted in the open ground, preferably during the rainy season. The cuttings of many kinds of plants can be rooted in dry weather if sufficient moisture is supplied. Cuttings of plants of unusually hard wood, as well as most of those having hollow stems, do not root well by the general method. They require special attention to the

nature of growth and form of cutting, greater humidity, and a special medium with bottom heat, giving it a higher temperature than that of the air above it, in the process of rooting.

The cuttings of plants of many kinds, particularly of field crops and hedges, are usually propagated directly in the soil where they are to grow. Such cuttings should be made of firm, sufficiently ripened wood of comparatively young shoots. This material naturally contains elaborated plant food either in readiness for or in the process of being transformed into new growth. The bark should also be plump and the wood brittle. The size of the cuttings depends somewhat on the nature of the plant, but in general, they should have a diameter varying from about $\frac{1}{2}$ to 1 inch and a length of from 6 to 10 inches. Cuttings, when planted, should be long enough to be held firmly in place by the soil and should have 2 or more nodes each. The basal ends, which are the portions to be put into the ground, should be cut through or just below the node with a clean, sharp knife.

Some cuttings root better from the node than from the internode, and those with an unusually large central pith should have the basal end cut squarely across the stem through the horizontal woody partition which strengthens the node. When cut in this way, no central pith is exposed, and the attacks of pith fungi, which otherwise may enter and cause decay, are prevented. The lower leaves of the cuttings should be cut off and those above, if of large size, should be reduced to about one-half.

The cuttings should be set either erect or in a sloping position in thoroughly prepared soil to a depth three-fourths of their length below the soil surface, which should be pressed down around them. It is generally believed that when the cuttings are set in a sloping position they are more easily kept firm and that less evaporation of moisture takes place from the buried ends.

Cuttings of sugar-cane and several of the large-sized forage grasses, stripped free of foliage, are laid horizontally in the furrows and are completely covered with several inches of soil.

Immediately after they are planted, the cuttings should be thoroughly watered and the soil kept in a moist condition during the time the roots are forming.

SPECIAL REQUIREMENTS OF CUTTINGS

Special treatment is necessary for the successful rooting of many kinds of soft-wood cuttings and particularly important for the rooting of those having herby structure. Both of these kinds of cuttings are quite exacting in reference to the rule that "root growth should start first and foliage growth later." The most important factors of special requirements to be considered are bottom heat and the right amount of moisture, including atmospheric humidity, proper shading, and protection against natural enemies. None of these factors can be well regulated in cutting beds on the open ground. Some form of propagating structure is necessary and may vary according to the needs of the propagator. It might be a propagating box, a hot bed, a lean-to, or some form of a glass house. Detailed descriptions with illustrations may be found in many publications dealing with the propagation of plants. The principles are practically the same in all of these forms.

Bottom heat in the propagating box may be furnished by a lamp or electrical apparatus, and the humidity held fairly uniform by the top, which should be tight and partially of glass to admit light. Increased humidity may be secured by putting a pan of water between the heater and the bottom of the soil or sand container. In the hot bed, which is constructed partially in the ground outdoors, the natural warmth may be increased by the fermentation of a 6-inch layer of fresh stable manure packed into the frame, with the soil medium placed directly on top of it. Where winter weather is more severe than in Hawaii, the layer of manure is often made 18 inches or 2 feet in thickness. Artificial heat, applied by means of hot-water pipes or electrical apparatus placed in or just below the soil, is not uncommonly used. Considerable humidity is maintained by having a tight, slightly sloping sash above. The propagating bed for a small horticultural establishment, where only a small amount of rooted cuttings are wanted at any one time, may be built in bench form above the ground in a lean-to shed with a single-slope glass roof. To obtain a comparatively cool air temperature within, the shed should be constructed on the north side of some other building. Such a lean-to need only be wide enough for the propagating bench and

the passage-way and have sufficient height from the ground for the convenience of the propagator while he is at work. (Fig. 2.)

This propagating bench should have a narrow row of horizontal ventilators placed just above the edge of the bench against the outside wall. Through these a little fresh air can occasionally be allowed to enter to keep the tops of the cuttings 5 or 10 degrees cooler than the soil in which the basal portions stand. Where large amounts of delicate, herby plants are to be propagated, a well-made propagating house with glass roof, raised propagating beds, bottom heat, and good ventilators should be erected. Such a house is described in detail and illustrated in *The Standard Cyclopedia of Horticulture* by L. H. Bailey (1, p. 925).

Enemies, such as rats, mice, and certain kinds of insects can be kept out by snug construction and screened ventilators. Ants

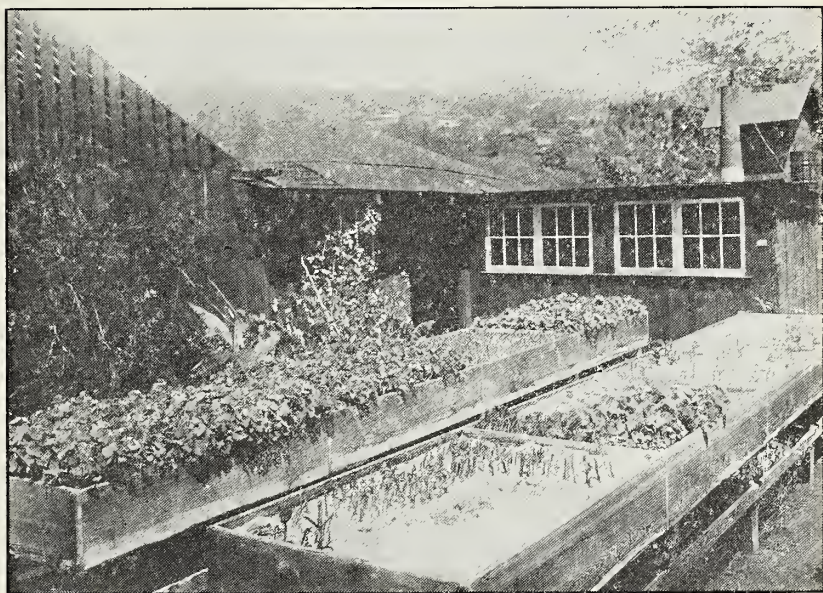


FIGURE 2.—Cutting benches in the open where many kinds of cuttings are rooted under Hawaiian conditions.

and other small creeping insects can be kept out by surrounding supports with water containers. The glass house affords an opportunity to control many destructive fungi by sterilized soil and fumigation.

In Hawaii, propagation is frequently accomplished in the slat house. Such a house consists of a substantial framework cov-

ered with laths or covered on the sides and top with rough fir strips 1 inch by 3 inches. In Honolulu, where the sunlight is strong and abundant, the spaces between strips are usually $1\frac{1}{2}$ to 2 inches. In Kona, where the weather is mainly cloudy and rainy in the growing season, 3-inch spaces are satisfactory, provided that the cutting bench has sash lids to prevent the entry of excess moisture and to check evaporation. In such propagating houses, best results are obtained with bottom heat. (Fig. 3.)

FRUITS

Avocado (*Persea americana*). In Hawaii, the avocado is propagated by seeds and certain forms of graftage. These particulars can be found in Hawaii Experiment Station Circular No. 6 (12).

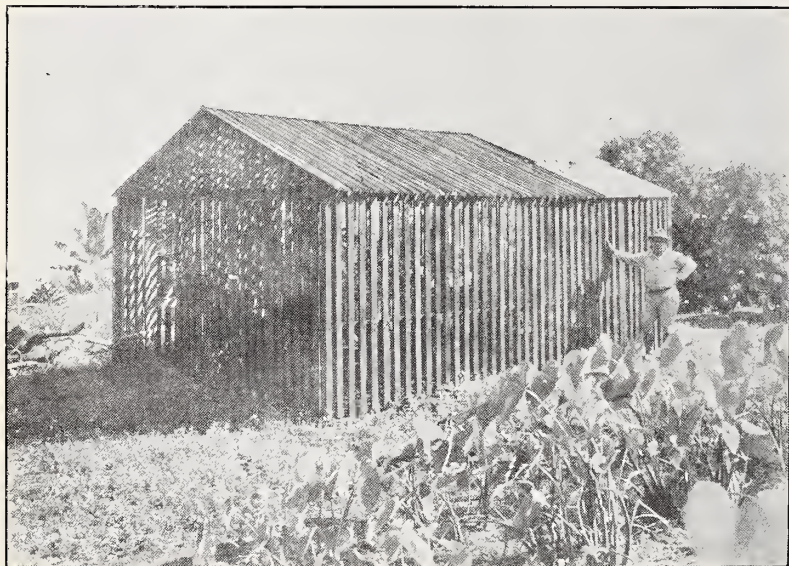


FIGURE 3.—The slat house, which has been proved efficient in propagation work in Hawaii.

Cuttings of avocados have been rooted at the Hawaii Experiment Station and elsewhere. This has been accomplished by using green wood of the current or previous year's growth, making the cuttings about 5 or 6 inches in length. These are placed to a depth of three-fourths their length in the propagating medium, consisting of equal parts of coarse sand and sphagnum

moss placed in 7-inch unglazed earthen plant pots. These are kept in a cool shaded propagating house in benches provided with bottom heat.

It has been found that cuttings form a callus best if wrapped in sphagnum moss for several weeks before they are put into sand, but only a small percentage root, and it is doubtful if the root system of such cuttings is as well developed and as vigorous as that of seedlings.

Banana (*Musa sapientum* and *M. cavendishii*). Seedless varieties of bananas are propagated vegetatively by means of suckers cut from the main stem, which, in the banana plant, lies mostly below the surface of the soil. Morphologically, these suckers are dimorphic branches; that is, they are of two forms from the same main stem of the plant. Commonly they are known as sword-suckers and broad-leaved suckers. Suckers of the former type also have large bases mostly composed of stored food and, consequently, grow faster and give a quicker return. In some countries the broad-leaved suckers are preferred for the establishment of permanent plantations in deep, heavy soil.

In Hawaii, the sword-leaved suckers are cut from the stem of the parent plant at an age varying from 2 to 6 months. The smaller sizes, with practically no expanded leaves, are called "peepers." Suckers are cut from the parent plant with a sharp spade-like tool called the "o-o." Any fibrous roots already formed, as well as any expanded leafage, should be cut away without cutting or bruising the surface of the base. The suckers should then be placed in the sunshine for several days to heal the cut made in removing them from the parent stem. When planted, the cuttings should be set low in the holes or furrows, and the soil tramped firmly about the base to a depth of about 4 or 5 inches.

The following type of cutting is often used in case of scarcity of propagating material or when a number of plants of some rare variety is desired. The cuttings are made of the old banana stump which is dug up and cut into sections or pieces, each of which should have at least one good bud. After the cut surfaces are healed by drying for a few days, the pieces are planted at a depth of about 8 inches. Such cuttings may be transported for considerable distances (9).

Bixa or Annatto (*Bixa orellana*). This is a large tropical American shrub with crimson seeds which are the source of annatto dye used in coloring fabrics, cheese, butter, and butter imitations. The plants are usually grown from seeds but are easily propagated from cuttings treated in the ordinary way.

Black Mulberry (*Morus nigra*). The black mulberry, which is indigenous to Western Asia, has been in cultivation for many years in Hawaii. In some localities it has become a part of the natural vegetation. In recent years the trees have been cultivated in home gardens for their fruit. At lower elevations the trees tend to branch near the ground, making the plant suitable for use in a hedge. The many branches fruit abundantly at an early age, sometimes producing two crops a year.



FIGURE 4.—Seedless breadfruit plants propagated from root cuttings.

Cuttings may be rooted at any season of the year, but preferably in early spring. They should be made of firm wood of the previous year cut in 6 or 8-inch lengths with a diameter varying from $\frac{3}{8}$ to $\frac{5}{8}$ inch. These should be set firmly in the sand-box or soil of the open ground, with about one-fourth of the upper end of the cutting exposed. If rooted in sand, they should be kept quite moist, but if in soil, less moisture will be required. In mak-

ing hedges, the cuttings are usually set directly in place. Other species of mulberry are propagated in much the same way.

Breadfruit (*Artocarpus communis*). The breadfruit is native of many of the tropical Pacific islands. Most of the varieties are seedless but may be successfully propagated vegetatively by root-cuttings (Fig. 1, D, and Fig. 4). Branch cuttings of firm wood from above ground will sometimes root. Propagation is best accomplished with roots taken from the parent tree near the surface of the soil at the beginning of the season of revived growth following the rest period after fruiting. By careful digging, roots of the size best adapted for the work are found. These should be about 1 to 2½ inches in diameter. They should be sawed off and carefully removed from the ground without bending or scarring, as such injury causes the stored plant food of the cambium to ferment and decay. The roots should be sawed into 5-inch lengths, the ends of which should be smoothed with a clean sharp knife. After a few minutes' exposure to dry the cut surfaces, the cuttings are ready for planting.

The best results at the Hawaii Experiment Station were obtained in a propagating bench 12 inches deep in a propagating house, although a fair percentage of successes was obtained in similar benches in the hot sunlight outside. In the propagating bench, a 2-inch layer of rich garden soil was spread and this was overlaid with 7 or 8 inches of coral sand. The cuttings were then placed horizontally 2 or 3 inches apart and gently pressed level with the surface and covered with 2 or 3 inches more of coral sand leveled and made firm with a piece of board. Such a cutting bench must be watered daily, and in several months the shoots, usually one to a cutting, appear above the surface. The new root growth tends to be a little slow, and for this reason it is best to leave the plants in the propagating bed for several months more. The layer of soil below the sand will encourage root growth and furnish the young plants some food before they need to be transplanted to large pots of rich soil for further growth before the trees are planted in a permanent place.

Carob or St. John's Bread (*Ceratonia siliqua*). Carob is propagated mainly by seed, although grafting has been accomplished, and cuttings have been reported to root. Complete information is given in Bailey's Standard Cyclopedia of Horticulture (1, p. 717).

Cassava (*Manihot utilissima*). The tapioca plant is a perennial shrub propagated by cuttings which are made of mature stems at any season of the year. These stems are cut into 4 or 6-inch pieces and planted 4 feet apart each way. Some growers set the cuttings to a depth of two-thirds their length in the ground, but best results have been obtained in Hawaii by laying them horizontally in the ground and covering them with several inches of soil.

Cherimoya (*Annona cherimola*). The fruit of the cherimoya is highly esteemed in all countries where it is successfully grown. In Hawaii, as in other tropical countries, it fruits only at altitudes having relatively dry temperate climate with little or no frost. It is essentially a subtropical fruit. In some countries it is propagated entirely by seeds, but where the trade demands a standardization of the size and quality of the fruit, the trees are propagated vegetatively by grafting and budding.

The ease with which the union takes place indicates the possibility of propagating them by cuttings, and this has been verified by experiment. Healthy branches of mature wood were taken from the tree during the period of dormancy and made into cuttings 5 or 6 inches in length and varying from $\frac{3}{8}$ to $\frac{1}{2}$ inch in diameter. These were set down in coral sand to a depth of four-fifths their length, having at least one bud exposed above the surface. With bottom heat, a large percentage was sufficiently rooted in 28 days for transplanting into pots of soil.

The cherimoya, like some other fruit trees, will come into bearing earlier if grafted onto a 2 or 3-year old seedling rootstock of the same species. Cutting methods of propagation might prove satisfactory where there is an abundance of propagating material.

Citrus (*Citrus species*). Citrus fruit trees (*C. species*), including orange, lemon, lime, pomelo, and citron, are described by such recognized authorities as Hume (6) and Coit (2) as being propagated by budding, grafting, cuttings, and layers. Citrus trees are grown also from seeds. Dr. Coit calls attention to budding as the universal method. The best results with vegetative propagation at the Hawaii Experiment Station have been in grafting 1-year old seedlings by either the bark or wedge graft (12, p. 10, 15).

In propagating citrus by cuttings, special methods must be

employed in order to obtain a number of rooted cuttings. Those of citron usually are comparatively easy to secure, and good results have been obtained with lemon. The cuttings should be made from well matured wood of one or two season's growth. Each cutting should be about 5 inches long and have 3 or 4 well matured buds. The basal end should have a smooth sloping cut at a node just below a bud. Such a cut at this point greatly facilitates the formation of a callus, which must be formed before the roots will develop.

Cuttings should be placed in the propagating bed of clean sand free from organic substances. The bed should be given bottom heat. The bed should have a glass sash lid that can be shut down snugly, leaving but 5 or 6 inches of space above the cuttings for retaining humidity. As soon as there is evidence of root growth, the sash may be left off to give the foliage more air until the rooted cuttings are sufficiently developed for transplanting into 4-inch pots of fairly rich, porous soil for further growth. Such rooted plants should continue growth in pots until the proper season for planting in permanent places in the open ground. Care should be taken at all times to prevent a root-bound condition.

Coffee (*Coffea arabica*). This species, which is the main source of the coffee of commerce, is a native of Abyssinia. Coffee was first planted in Hawaii in 1817 and has been grown commercially in Hawaii since about 1830. The annual crop for the year 1931-32 amounted to more than 9,500,000 pounds.

In most countries coffee is grown mainly from seed. True varieties are maintained in one or two countries by vegetative methods of propagation. The upright branches are used for cuttings and scions in grafting; lateral branches cannot be used for propagating trees as their function is to produce fruit. Cuttings, when taken from the upright branches previous to the blossom season in the spring, will root freely. The cuttings are best made sufficiently long to have two nodes and a diameter of $\frac{1}{2}$ or $\frac{3}{4}$ inch. They should be set well down in propagating beds of soil in a comparatively cool place where considerable moisture may be supplied. The cuttings root and are ready to be transplanted in a few months. Cuttings will retain varietal characters but certain hybrid varieties have weak root systems which do not resist

unusual soils or attacks of nematodes. Such varieties should be perpetuated by grafting scions on more resistant rootstocks.

Date (*Phoenix dactylifera*). The comparatively easy culture of date palms in parts of Hawaii indicates the possibility of a small date industry in this Territory. Most of these palms have been grown from seed, but the better grades of fruit are of known horticultural variety. The plants are propagated as off-shoots cut from the parent tree having pistillate flowers, as the date palm is dioecious. Off-shoots are usually produced above ground about the base of the young palm before it comes into full bearing, which is a period of 10 or 12 years. The off-shoots should not be removed until they are 5 or 6 inches in diameter and have a weight of about 15 or 20 pounds, development which requires about 2 years of growth. They should be removed during the summer months by cutting in and down along the line of cleavage between them and the main trunk, with a strong chisel or sharp o-o. The leaves should be closely pruned, and if there is delay and much handling, as in shipment, the basal end should be protected against bruising and drying by a layer of damp moss held in place with burlap.

The cutting should be planted in previously irrigated and well-settled soil to a depth of 4 or 5 inches, so that the bud in the center is not below the irrigating water level. For convenience in watering, a shallow basin of earth should be made about the base, in which 2 or 3 inches of barnyard litter should be spread. This should be kept moist by frequent watering. The cuttings should be fully protected from the wind. To prevent too rapid evaporation, the cuttings may be wrapped with burlap until new growth appears. Experiments in Southern California have shown that a large percentage of cuttings may be successfully rooted in the very hot, humid atmosphere of a tight board propagating shed. After the roots are well established, the young palms may be transferred to permanent places in the date orchard.

Eugenias (*Eugenia species*). The species of *Eugenias* included in the vegetative-propagation experiments at the Hawaii Experiment Station during the past two years are as follows: mountain apple (*E. malaccensis*); rose apple (*E. jambos*); Java plum (*E. jambolana*); (*E. grandis*); water apple (*E. aqua*); Surinam cherry (*E. uniflora*); Brazilian cherry (*E. dombeyi*); and guava berries (*E. floribunda*). These species are usually

propagated by seed, but cuttings of the first five were successfully rooted in ordinary propagating beds of sand without bottom heat. They were given special care in transplanting the rooted cuttings to pots of soil, and in watering and shading preparatory to outside planting. Judging from their action in cutting and grafting experiments, we believe that cuttings of all of these will root if tried in the propagating house with bottom heat.

Feijoa or Pineapple Guava (*Feijoa sellowiana*). This guava-like plant is indigenous to a portion of the subtropical campos or plains of South America. It does well in parts of California where improved varieties, which are considered superior to the guava, have been developed. Plants at the Hawaii Experiment Station in Honolulu have grown with considerable vigor but have not set fruit, presumably due to climatic conditions at this low altitude. The same abnormal state has been noted in other tropical countries having similar conditions. Hawaii, no doubt, has some higher altitudes where this species will fruit, and the Station is experimenting to verify this belief.

The feijoa reaches an ultimate height of 10 or 15 feet but can be maintained as a comparative low hedge by pruning. The attractive foliage is composed of rather small, oval, entire leaves, green above and silvery pubescent below. The flowers are bisexual, 1½ inches across, and have a combination of colors which is particularly attractive. The fruit is oval to oblong, 2¼ to 3 inches long, and good varieties are highly esteemed for their pleasing odor and flavor. It can be eaten either raw, stewed, crystallized, as a dessert, or made into jam and jelly.

The feijoa is propagated by seeds and by cuttings and various forms of graftage. The wood of cuttings should be firm and preferably of the current year's growth. The pieces should be cut about 4 inches long and the basal end smoothed with a sharp knife at or near a node. The best results in rooting cuttings have been obtained in cool weather with bottom heat, the time required being about a month. In ordinary summer conditions, several months are often required with a medium of rich garden soil incorporated with an equal portion of coarse sand. In some subtropical climates, the cuttings for a hedge are set in place during the cooler months. Hedges are also made of seedlings, and choice varieties are usually propagated by grafts, the scions being placed on vigorous seedling rootstocks of the same species.

Figs (*Ficus carica*). The fig is native of the warm-temperate region of Asia Minor. It has been in cultivation from ancient times and has spread to most parts of the world where the climate is warm enough for its culture. Many new varieties are in cultivation and excellent preserving methods have been developed. Since 1910, the Hawaii Experiment Station has introduced and experimented with a number of varieties. Those of most importance at present are the Turkish Brown, the Black Mission, and the Kadota.

Fig culture is comparatively simple, but the trees fruit better if pruned, fertilized, and kept free from insect pests. The maturing fruit is sometimes infested with fruit-fly larvae, and mynah birds are a persistent pest for the ripening fruit. At lower elevations the trees tend to branch near the ground. Fig growers in the Gulf States, however, do not find this form of top a disadvantage in commercial orchards.

The fig is usually propagated by cuttings made from well ripened wood of the previous year. The cuttings do best if taken during the rest period after the tree has shed its foliage. It is customary to make the cuttings about 6 or 8 inches long, with the basal end cut at a node. They may be rooted in boxes of soil or sand, or in the open ground, which is more or less sheltered from severe winds. The cuttings, being fruit-wood, tend to fruit very early, but crop production really does not begin until the third or fourth year. In moist localities, the fruit is used mainly as fresh fruit. New varieties are produced from seed, and grafting of fig plants is sometimes practiced.

Grape (*Vitis species*). Grape vines are easily propagated by cuttings, and this method is employed to perpetuate varieties. At the Hawaii Experiment Station, numerous varieties have been propagated from 1-year old wood taken from the parent vine while growth is dormant, or from cuttings received by mail from California.

Such cuttings are from 8 to 10 inches in length and possess 2 or more nodes having buds. The basal end is cut sloping at a node just below a bud, and the top cut about an inch above a node (Fig. 1, B). The sloping cut gives more space for callus and is less apt to be crushed by the cutting shears. These cuttings are put directly into the outdoor sandbox containing clean coral sand 1 foot deep. In this the cuttings are placed with three-

fourths their length in the sand, and they are kept thoroughly moistened by watering once every day. The cuttings are usually rooted ready for transplanting into soil in from 5 to 8 weeks.

Horse-Radish Tree (*Moringa oleifera*). This useful tree is native of India, from where it has spread to many other tropical countries. P. J. Wester (15) states it is of general distribution at lower altitudes in the Philippines. It is also reported both as being in cultivation and as an escape in parts of Puerto Rico and Cuba. It is not exacting in its requirements and withstands considerable drought. The various species of Moringaceae are of rapid growth, the tree reaching a height of 25 feet, and having a soft wood and corky bark. The young parts are pubescent; the leaves are thrice pinnated, and from 1 to 2 feet long; the flowers are white or yellowish white, about an inch in diameter, and fragrant. The fruit is a slim, 9-ribbed seed capsule, sometimes $1\frac{1}{2}$ feet long, containing 3-angled, winged seeds which are the source of "ben oil," a non-drying oil used in the arts. The young pods, tender shoots, leaves, and roots are edible. The latter has a particularly pungent, horse-radishlike flavor which probably suggests the common name of this tree, which is propagated by seed or cuttings. Cuttings are easily propagated in almost any kind of medium. The best cuttings are obtained from wood of the previous year.

Litchi (*Litchi chinensis*). It is with considerable difficulty that the litchi tree is propagated vegetatively. Ordinary methods of propagation by cuttings are unsatisfactory. The United States Department of Agriculture has worked out a method of rooting the litchi by cuttings. It is the result of a number of trials and requires rather complicated apparatus and a great deal of care in maintaining certain conditions of warmth and moisture during the entire process.

The first procedure is the preparation of a propagating case or "sweat box." A convenient size is 2 feet 4 inches wide, 2 feet 8 inches high, and 3 feet 5 inches long. The frame is of wood with the sides and the top of glass to admit light. In the bottom is a one-plate electric heater, over which is a galvanized iron pan about an inch in depth and nearly as large as the inside measurements of the bottom of the sweat box. Over the pan is a galvanized screen of $\frac{1}{4}$ -inch mesh, upon which is placed a 2-inch layer of wet sphagnum moss. The door of the box must

fit snugly to prevent evaporation. The construction must be such that a temperature of 85° or 90°F. and great humidity may be maintained within the sweat box at all times during the rooting process.

In preparing the cuttings, care should be given to select small vigorous branches of fairly mature wood. After they are removed from the parent tree they should be immediately immersed in water. The base of the cuttings should be trimmed with a sharp knife and about half of the foliage removed, leaving the length of each about 5 or 6 inches. They are then tied to 6-inch plant labels and each shoved down into the peaty soil in a 3-inch plant pot (Fig. 1, E). The soil may be a mixture of equal parts of heavy rich soil and coral sand. The bases of the cuttings should just touch the soil and pots should be set in the layer of moss of the sweat box, the temperature being maintained at 85° or 90°F. Because of the heat and humidity the base of each cutting will form a callus in about 10 days and will be fairly well rooted in 20 or 30 days. By this method, 80 percent of the cuttings have been successfully rooted. The chief difficulties experienced have been in removing the rooted cuttings from the sweat box. This must be accomplished gradually, using two other boxes, in which there is a gradual decrease of temperature and humidity.

This method of rooting cuttings has not been satisfactory at the Hawaii Experiment Station, possibly on account of unsatisfactory equipment. The litchi, however, has been very satisfactorily propagated in considerable numbers by the side-tongue method of grafting, which is described in detail in Hawaii Experiment Station Circular No. 6 (12).

Loquat (*Eriobotrya japonica*). The loquat, which is occasionally grown in Hawaii, responds to vegetative methods of propagation. It has been multiplied by cuttings, but this method is not recommended for commercial propagation. Varietal characters are retained by budding and grafting. In California, it was found that the best time of the year to make cuttings is in the fall when the spring growth has become well hardened and is more or less dormant. Only wood of the present season's growth should be used. The cuttings, 5 or 6 inches long, should be placed under glass in the sand of an ordinary cutting bed and

treated in the same manner as other hardwood cuttings. Bottom heat, although not necessary, will accelerate the rooting.

Macadamia Nut (*Macadamia ternifolia*). Experiments have shown that true varieties of the macadamia nut tree may be perpetuated by grafts, cuttings, and air-layers. Recently a very satisfactory percentage of successes in vegetative methods of propagation of nursery stock, growing in the field at the Kona substation, indicated the possibility of working out a more simple method of multiplying the plants by cuttings. The earlier successes of vegetative propagation of this tree are described in Hawaii Experiment Station Bulletin No. 59 (10).

The propagating material found most suitable consists of straight, heavy terminal branches of mature wood, $1\frac{1}{2}$ to 2 feet long, and a basal diameter of $\frac{1}{2}$ inch. The leaves of the lower two-thirds of the stem should be cut off, most of the remainder clipped in part, and the terminal leaves left entire. The cuttings should be placed to a depth of half their length in a deep medium of porous soil with good underdrainage. The temperature should range from 65°F. at night to 75°F. in the daytime, the natural variation at about 1500 feet altitude in winter months. Protection from the unusual heat of midday can be given by an overhead shelter of burlap. The atmosphere should contain considerable humidity and the soil should be kept well moistened. Root development of the cuttings should be sufficient for transplanting in from 3 to 5 months. Great care should be taken in removing the plants from the propagating bed. The soil should be very wet and as few roots should be cut as possible. This should be done in the rainy season, to secure great humidity of atmosphere where the plants are set.

Monstera or Ceriman (*Monstera deliciosa*). This tropical climber has been in cultivation in Hawaii for its fruit and ornamental values for more than half a century. It is propagated by large stem-cuttings, each of which should contain several nodes with buds. The cuttings are rooted in a propagating bed or in individual containers in a medium of equal parts of sand and rich garden soil. The ordinary temperatures at lower elevations in Hawaii are satisfactory. When the growth indicates that sufficient roots have developed, the plants may be transferred to larger containers or set in permanent places in the ground. It is not an uncommon practice to root a cutting in the soil at the

base of the tree to which, as it grows, the *Monstera* will cling. The fruit is usually seedless in Hawaii, but occasionally a few fertile seeds have been found and germinated at the Hawaii Experiment Station.

Natal Plum (*Carissa grandiflora*). Although this plant produces edible fruit, it is usually grown in Hawaii for its ornamental effect and hedge value. It is propagated usually from seed, for by ordinary cutting methods it roots with difficulty. However, the cuttings have been found to root easily when placed in a cutting bed with bottom heat. The rooting of small cuttings very successfully by a special method in Florida has been reported. This method consists of notching small branches while they are still attached to the plant, making a cut half way through the stem 3 or 4 inches from the tip. The branch is then bent downward and allowed to hang attached until the end of the second month, when the callus will have formed on the cut portion. Then the cutting may be removed and placed in moist sand under a partial shelter, where it will require another month to develop roots.

This plant is also propagated by layering and budding. There are several closely related species, the propagation of which is similar to that of the Natal plum.

Olive (*Olea europea*). Olive trees are occasionally found growing in Hawaii at altitudes up to 3,000 or 4,000 feet. They rarely fruit below 1,000 feet but are valued for their ornamental and decorative uses. The olive is propagated by seeds, layering, and cuttings, and in countries where commercial varieties are cultivated for their fruit budding and grafting are practiced. Propagation by cuttings is of two kinds according to size, small and large.

Small cuttings are made of firm wood of the current year in January or February. Both tips and second cuts are made into 3 or 4-inch lengths, with about half of the leafage left on each cutting. They are immediately set about an inch apart in a propagating box of sand, the medium being about 4 inches deep. If kept well watered and at about 80°F., they will root sufficiently for transplanting into 3-inch pots in about 3 or 4 months.

Large cuttings are made of well-matured wood in December. Each cutting should be from 8 inches to 12 inches in length and

should have a diameter varying from $\frac{1}{2}$ inch to $\frac{3}{4}$ inch. The foliage should be removed and the basal end cut squarely through the woody cross-partition of the pith at the node. This type of basal cut prevents the development of a pith rot. The cuttings are tied in bundles, packed in damp sand, and stored in a cool place until March, when they should be set in the open ground to a depth of about three-fourths their length. The soil should be pressed firmly and kept moist but not wet. In this condition a fair percentage will usually root.

Papaya (*Carica papaya*). Papaya has been successfully propagated in several countries. At the Hawaii Experiment Station, cuttings have been rooted in several ways. Large cuttings, about 2 feet in length, rooted more easily than the small ones, when tried in deep beds of clean coral sand in the propagating house. Without bottom heat, the cuttings required some time to develop sufficient roots for transplanting.

The only practical results were obtained with large branches 2 or 3 feet in length, with a basal diameter of from $2\frac{1}{2}$ to 3 inches and with leaves of the lower half cut off, leaving leaf-stalk stubs 3 or 4 inches long. These were set about a foot deep in the field, the soil of which consisted of volcanic cinder partially decomposed. The cuttings were set during a rainy period. In a few months, these cuttings began to grow and to set fruit, beginning only a few inches from the ground. In quality, the fruit was similar to that of the parent tree but subject to change in form and flavor at different seasons of the year, which is a condition common to practically all papaya plants. The subject of rooting papaya cuttings is discussed in Hawaii Experiment Station Bulletin No. 61 (11, p. 24).

Passion Fruit (*Passiflora species*). The edible varieties of passion fruit cultivated in Hawaii are as follows: giant granadilla (*Passiflora quadrangularis*); purple passion fruit (*P. edulis*); yellow passion fruit (*P. edulis* var. *flavicarpa*); sweet granadilla or water-lemon (*P. ligularis*); bell apple (*P. laurifolia*). The fruit of *P. mollissima* and *P. maliformis* is sometimes eaten. The plants of practically all of these species have been propagated from cuttings.

At the Hawaii Experiment Station, the giant granadilla cuttings have been easily rooted in ordinary sandboxes exposed to outside conditions. Cuttings of mature wood of the first or

second year's growth are made into 6 or 8-inch lengths, each piece having at least two nodes. These are set in a box of coral sand with a depth of about 1 foot. The cuttings should be set to a depth of three-fourths their length in the sand and kept well moistened. The growth of roots and foliage will usually be sufficient for transplanting into soil in 30 days.

The other species are more difficult to root, but if the cuttings are taken from mature stems before the plants come into blossom, a fair percentage can be rooted in the propagating house with bottom heat. All these varieties of edible passion fruit may be propagated from seeds, but true varieties can be retained only by cuttings and ground layering.

Pineapple (*Ananas sativus*). The pineapple, which is cultivated for its fruit, is usually seedless. It is propagated mainly by cuttings. The parts used are crowns, suckers, and ratoons. The crown is the short, leafy stem at the top of the fruit; suckers are branches that develop along the stem above ground; and the ratoons develop from the nodes of the rhizome below the surface of the soil. These parts are removed from the plant, all but a few of the terminal leaves of each are removed, the basal ends of the stems are cut squarely, and all cuttings are placed on the ground with the cut surfaces up, to dry in the sun for several days before they are set in the field.

Occasionally is found a fruit which contains seeds, but in plant breeding for improvement of varieties, the flowers of known varieties are cross-pollinated and seeds are thus produced which, when germinated, will give hybrid plants. From these possibly some new and desirable plants may be produced. The quality is determined by the fruit and, if satisfactory, the plant is then propagated vegetatively.

A new and rapid method of vegetative propagation for such valuable plants has been worked out by Mr. E. A. Walters (14). The pineapple plant, preferably before the formation of the fruit stem, is stripped of all leaves except the last 6 or so, which form the rosulate, young shoot. The rhizome and aerial portion of the stem, when freed from roots and scales, is then cut with a sharp knife into clean cross-sections not more than $\frac{1}{5}$ inch thick. Such sections will carry from 3 to 4 dormant buds. They are then put into a 2 to 5 per cent solution of potassium permanganate for about 10 minutes, after which they should be removed

and allowed to drain. They are then planted in a flat position on a prepared bed of light, moist soil. Growth from the dormant buds takes place within a week or two, depending somewhat on the temperature and nature of the plant from which the cuttings were made. After a little more growth, the sections are carefully lifted without injury to rootlets that may have appeared. They are then cut into several triangular pieces, each part of which must have at least one of the sprouting buds. They are again dipped into the potassium permanganate solution, replanted in a propagating box of light soil, and watered with a solution of ammonium sulphate. Within a short time the embryo pineapple plants with good root systems may be transferred to larger containers of soil in the greenhouse for further growth before setting into the field.

Pomegranate (*Punica granatum*). The pomegranate is propagated easily by seeds, cuttings, and layers. Varieties are maintained easily by rooted cuttings. These are made of mature young wood from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in diameter and about 8 inches long. Pomegranate cuttings should be set firmly in the open propagating bed with only about one-fourth of the length and one node exposed.

Prickly Pear or Panini (*Opuntia tuna*). This form of cactus is adapted to semi-arid sections where it has considerable promise as a forage for cattle. It is propagated naturally by means of seeds and vegetative parts. There are several more or less spineless varieties in cultivation. These are propagated by means of cuttings which are made of stem joints, often incorrectly called leaves. A suitable cutting consists of a single joint, although larger pieces of several joints are sometimes used when there is plenty of material. The section should be cut off at the basal constriction as this will give less cut surface to heal over and this part of the stem is more naturally a root-producing surface. If the cuttings are juicy following a period of wet weather, they should be dried for several days before setting in the ground. They are best set by hand in damp soil at a depth of about 4 inches. The soil should be made firm about them. Care should be taken to avoid setting the cuttings during wet weather or following the operation with heavy irrigation. In field planting, the cuttings should be set about 3 feet apart in rows 6 feet apart.

Several varieties of cactus have been in cultivation at the Hawaii Experiment Station, and experiments conducted at the Chico Station in California indicate that the cactus plants of a young field should not be fed off until the plants have made 3 or 4 years' growth, after which the yields will be somewhere between 20 and 25 tons per acre per year. Full particulars with reference to the culture of the cactus may be found in the United States Department of Agriculture Farmers' Bulletin No. 483 (5).

Sea Grape (*Coccoloba uvifera*). In the West Indies, this ornamental tree is described as having edible fruit and wood of good quality and color suitable for cabinet work. In Hawaii, it is ornamental and recommended for planting near the seashore. It is easily propagated by seeds and the cuttings may be rooted easily in sand or light soil by the general method. (Fig. 1, A.)

Tree Tomato (*Cyphomandra betacea*). This plant may be grown by seeds or cuttings. Cuttings are made of growing shoots treated in the ordinary propagating bed without bottom heat. For a description of cultural methods, see "Manual of Tropical and Sub-Tropical Fruits" by W. Popenoe (13, p. 452).

Vanilla (*Vanilla planifolia*). The vanilla plant is a climbing orchid which grows best in a hot humid climate. It is occasionally found in cultivation in Hawaii. Propagation is accomplished mainly by mature stem cuttings made of lengths varying from 2 to 12 feet. No tender tips should be used. Some growers prefer laterals, because they have shorter joints and possess more root-producing nodes. Cuttings should be taken after the crop is removed and when the dry season or period of dormancy appears to be about over. Only healthy, vigorous material should be used. Long cuttings make more rapid growth than short ones. Twelve-foot cuttings will often come into flower in 18 months from planting, while those 2 or 3 feet long will not flower abundantly until the third year. Vanilla plants naturally grow in the woods which produce a partial, evenly checkered shade. They always require supports, such as trees or posts, preferably with a moderately smooth bark to which the aerial roots may easily become attached. Round posts, 8 or 10 feet long with a diameter of about 5 or 6 inches, set several feet into the ground, are satisfactory. These are usually placed about 8 feet apart. The soil, which should be rich in humus, should be spaded up and the cuttings set, one to each post, with the basal end of 3 or 4 nodes laid hori-

zontally in the ground at a depth of about 3 inches and covered with a heavy mulch consisting of decaying leaves, dead grass, and other forest litter. The part of the cutting above ground should be curved up at the base of the post and tied upright at intervals along the post, so that the aerial roots will easily contact with the bark. Where trees with trunks of a foot or more in diameter are used as supports, two cuttings may be set on opposite sides of each trunk. Soon after setting the cuttings, aerial roots develop and adhere to the bark of the support.

Vanilla plants require but little attention beyond this training for the successful production of vanilla beans. Very complete accounts of the culture of vanilla may be found in "Tropical Gardening and Planting" by H. F. Macmillan (7, p. 343) and the Puerto Rico Agricultural Experiment Station Bulletin No. 26 (8).

VEGETABLES

Ginger (*Zingiber officinale*). Ginger is easily multiplied by cuttings of the thickened underground stems placed directly in the soil where they are to grow. It requires shade and moisture, and as it is a short-period crop, proves a splendid intercropping plant in young coffee orchards before the time when the trees need all of the space. The cuttings should be placed 1 foot apart in the row and covered entirely with soil.

Horse-Radish (*Armoracia rusticana*). The common garden horse-radish is an herb-like perennial. The main root is used as a relish with meat and some other foods. It is occasionally grown in cool localities in Hawaii.

Horse-radish is propagated by root-cuttings. When the main roots are harvested, the smaller branches, which have a diameter of from $\frac{1}{4}$ to $\frac{1}{2}$ inch, are made into cuttings varying in length from 6 to 12 inches. The upper end is cut straight across and the lower end is cut slanting. The cuttings are then tied up in small bundles of a dozen each and stored in a cool place in damp sand for a few weeks before planting.

The cuttings grow best in a deep, rich, and moderately damp soil, preferably set 1 foot apart in rows 3 feet apart. They should be placed vertically or in a slanting position, with the top portion several inches below the ground surface. Where the winter months are the growing season, the cuttings should be planted in

the fall so that each will develop a mature main root ready for harvesting in the early part of the following summer.

Mint: Peppermint (*Mentha piperita*); **Spearmint** (*M. spicata*). These herbs are sometimes cultivated in home gardens in Hawaii and may escape and grow as a part of the natural vegetation in places which remain moist all of the year. They are easily propagated by cuttings and rapidly spread by runners. The plants sometimes seed, but are rarely grown from seed.

The cuttings are usually made from the creeping stems and the basal ends. The cuttings should be set several inches deep in a place where the soil can be kept moist at all times. The cuttings root rapidly and the ground becomes filled with roots and underground stems which send up a thick ground cover of leafy shoots.

Rhubarb (*Rheum rhaponticum*). Rhubarb grows well in parts of the Territory of Hawaii which range from 2,000 feet to 4,000 feet in altitude. The leaf-stalks, the portions usually eaten, are pulled from the main underground stem or rhizome. They may be grown from seeds, but true varieties are retained and early crops produced by vegetative propagation, using cuttings or natural divisions of the fleshy underground stem.

In Hawaii, the cuttings are taken in late summer when the plants are somewhat dormant. Each cutting should consist of at least one good bud and a portion of the stem containing stored food. The cuttings should be set 3 feet apart, several inches below the surface of a rich, moist soil. Plants grown in this way will live for a number of years, and after the first season, will produce large numbers of roundish leaves, each of which has a leaf-stalk from 18 to 24 inches long.

When harvesting, always leave a few leaves on each plant to carry on the plant processes. Cut the leaf-blades from the leaf-stalks, so that the stalks will retain their crispness. When the leaf-stalks are pulled as they should be, they will separate naturally from the main stem without leaving a portion to decay.

Sweet Potatoes (*Ipomoea batatas*). Sweet potato plants are propagated from vine cuttings and from slips or sprouts developed on the fleshy roots. In Hawaii, terminal stem-cuttings are used almost exclusively. These make quick growth and tend to be free of insect pests. Older parts of the stems are more apt

to be infested with eggs or larvae of the stem borer and may lead to the infestation of new fields with that pest.

The terminal cuttings may be taken at any time during the year. Each cutting should be 1 foot long. The large leaves should be clipped from it. If the cuttings are not to be planted immediately, they should be wrapped in wet paper or wet cloth. Either cuttings or slips may be kept for a week if properly packed in damp sphagnum moss and wrapped in oiled paper and brown wrapping paper. Both cuttings and slips are usually planted directly in the place where they are to be grown. In ordinary field conditions, the cuttings are set about 2 feet apart on ridges 3 or 4 feet apart. Where mound planting is practiced, several cuttings are set to each mound. The mounds are from 2 to 3 feet apart. Flat planting is practiced in sandy land or in land where the soil is unusually dry during a part of the year.

Sweet potato slips are easily obtained from the fleshy root, the surface of which has the function of producing numerous adventitious buds. The buds, with the right conditions and the stored food, rapidly develop into slips. Smooth, healthy sweet potatoes of medium size and good form should be selected. These should be soaked for about 15 minutes in a 1 to 1,000 solution of bichloride of mercury to kill all surface-borne organisms. After the moisture has dried, the potatoes should be placed separately 3 inches below the surface of a bed or box of clean sand, which has a depth of about 8 inches. The sand should be kept moist and a temperature of 85°F. should be maintained. In about 3 or 4 weeks, a number of sprouts will be from 4 to 6 inches long, large enough to pull and transplant. The removal of the slips will cause the development of another lot of slips, and even a third crop of slips may often be produced from each fleshy root.

Some growers develop the slips by bedding the sweet potato in a medium of chaff, rice hulls, or sphagnum moss. A number of rootlets are formed on each slip by the time it is long enough to pull. If watering is withheld for 2 or 3 days before they are pulled, the slips will be hardened sufficiently to withstand transplanting. Unless the weather is rainy when the transplanting is done, the slips should be watered immediately after they are set.

Taro (*Colocasia antiquorum esculentum*). This herby plant, at maturity, consists of a fleshy rootstock or tuber from the top of which arises a bunch of large leaves. The tuber reaches maturity in from 10 to 14 months, depending somewhat upon the variety and the growing conditions. When it is harvested, half an inch or less of the top of the tuber, including the crown bud and leaves, is cut off and the foliage is reduced to a few leaf-stalks about 6 inches in length, which form a crown cutting. These crown cuttings, commonly called "hulis" in Hawaii, are then planted in the field where the new crop is to be raised.

In Hawaii, two different methods of planting have been practiced, mound planting and flat planting. In the former, the surface of the field is dug up into little mounds about 2½ feet in diameter, the intervening spaces being left for irrigation water. About 5 or 6 cuttings are set 1 foot apart in a circle in each mound. The cuttings are set to a depth of 3 or 4 inches, with the upper ends of the stubs of the original leaf-stalk exposed.

When the system of flat planting is employed, the cuttings are set in rows about 2 feet apart. The planting by either method is immediately followed by irrigation to dampen the soil. In about one month, the cuttings will have developed sufficient roots to permit the field to be flooded, a condition in which it should be kept until the new crop of tubers is ready to be harvested.

Watercress (*Nasturtium aquaticum*). This is a perennial plant which thrives in slow-running, shallow streams or in moist, shady places. It is propagated from seeds or stem-cuttings. Stem-cuttings are made of various lengths of mature stems and are set in trenches near the edge of the water or in damp garden soil. They root easily and quickly and are ready to cut for use in a few weeks.

White Potatoes (*Solanum tuberosum*). The plants of white potatoes are propagated by cuttings and seed. The latter method, however, is but little practiced except in the propagation of new varieties. No doubt, the long and extensive practice of vegetative propagation has caused the potato plant to lose its seeding habits to a considerable extent.

Cuttings are made of tubers of the previous year's growth. The tubers, which are the thickened portions of underground stems, consist mainly of stored food and dormant buds which

remain alive during periods of drought or other unfavorable growing conditions.

To retain desirable characteristics and habits, careful attention must be given to the selection of the tubers and to their preparation as cuttings. The tubers should be mature, healthy potatoes of fair size and with "eyes" or buds comparatively dormant. Under proper growing conditions, each bud will make a separate plant. The potatoes should be cut into chunky pieces, each about $1\frac{1}{2}$ or 2 ounces in weight and having one bud on the natural surface but not adjacent to the cut edges. The fresh cuttings should be spread out in a sheltered place to dry slowly for 2 or 3 days. About one day before planting, it is well to dust the pieces with powdered lime or flowers of sulphur to reduce the shrinking and prevent heating and decay.

In planting, the pieces or cuttings may be dropped by hand or machine from 10 to 14 inches apart in furrows 2 to 3 feet apart, the distance depending upon the type of cultivation planned. The cuttings should be covered to a depth of 3 or 4 inches. About 7 or 8 bushels of cut tubers are required to plant an acre. Potatoes in most places run about 60 pounds to the bushel.

GRASSES

Bermuda Grass or Manienie (*Cynodon dactylon*). Bermuda grass, or Manienie, is a favorite grass in Hawaii for both pasture and lawn. It spreads by means of long creeping runners which root and shoot at the nodes. When the shoots have reached 1 or 2 inches in length, the runners can be made into cuttings of a single shoot each. To make a lawn, they may be set from 4 to 6 inches apart in damp soil which has been dug up, pulverized, and leveled to grade. Similar plantings are often made by the separation of grass clusters into a number of smaller portions, each portion consisting of one or more plants with active roots. These are set in the same manner as true cuttings. With sufficient moisture, they will soon spread, making a complete ground cover.

Buffalo or St. Augustine Grass (*Stenotaphrum secundatum*). Buffalo grass is a creeping perennial which spreads rapidly in moist places by means of runners. In Hawaii, it is used as a pas-

ture grass to some extent and as a lawn grass, particularly in shady places. It is established by means of division and cuttings, the latter being made mostly from runners. Single-node cuttings usually have one side shoot each. These root easily when set in a rich soil with good underdrainage. Cuttings or separations may be set from 6 to 12 inches apart. Closer plantings naturally will give complete ground cover in a shorter time. The beginning of the wet season is the best time to set cuttings, for this grass thrives with abundant moisture. Frequent cutting with the lawn mower is important, for this grass is difficult to control.

Elephant or Napier Grass (*Pennisetum purpureum*). Elephant grass and several related species are now used as forage for livestock in Hawaii. Elephant grass grows to a height of from 10 to 14 feet and has a stem about $\frac{1}{2}$ inch in diameter. For propagation, these should be made into cuttings from 6 to 10 inches long, each of which should have several nodes. The leaf sheaths, which cover the buds, should not be removed. The cuttings should be laid down horizontally 1 to 2 feet apart in rows 6 feet apart and covered with an inch of soil, which should be made firm over them. As with practically all cuttings, the planting should be followed with a thorough watering. The growth is rather slow at first, but during the second year each plant sends up many shoots.

Sugar-Cane (*Saccharum officinarum*). Sugar-cane is extensively propagated by cuttings in Hawaii. The cuttings may be made and planted at any season of the year. On the plantations they are often incorrectly called "seed cane," but true seeds are rarely produced by the sugar-cane plant except with special treatment, as in breeding experiments.

Cuttings are selected from vigorous, healthy stalks several months previous to the appearance of the blossom. Usually only 3 or 4 cuttings are taken from the upper portion, and the tip is discarded. Several months after the blossom period, the upper portion of the stalk usually develops side shoots 3 or 4 feet in length, which are sometimes called "lalas." These may be made into cuttings, the tips being discarded. Each cutting should have three or more nodes and each node, a bud alternately arranged in two rows on opposite sides of the stem.

For uniformity of growth, the cuttings should be laid in

the row in such a position that the buds will be on the sides. They may be laid in one continuous row lengthwise in the furrow or in two parallel rows near each other in the furrow according to the variety and the strength of the land. The cuttings should be covered with 1 or 2 inches of soil and then watered. In from 6 to 10 days, depending on conditions, the shoots will appear above ground.

HERBY AND SHRUBBY PLANTS

Many of the common herby plants such as begonias, coleus, petunias, verbenas, geraniums, and the common garden tomato, are easily rooted from cuttings, the best method being under glass in beds of clean sand with bottom heat. Special methods for these plants are described in U. S. Department of Agriculture Farmers' Bulletin No. 157 (3).

Dracaenas (*Dracaena species*). *Dracaena* species, which are closely allied to ti plants, include numerous hybrids varying in color of foliage and in form. Most of these are easily propagated by stems and root-cuttings. The stem-cuttings consist of short lengths of firm wood which easily root in damp soil. The root-cuttings should be vigorous roots about $\frac{1}{4}$ inch in diameter cut into lengths of about 2 inches.

These pieces should be buried horizontally below the surface of clean, coral sand in the bed of the propagating house where bottom heat can be provided. The surface of the bed should be covered with a thin layer of sphagnum moss or grated pith of the coconut husk. This material will tend to prevent the sand drying at the time the delicate adventitious buds are forming. In a few weeks, sufficient roots will be established to permit transplanting the cuttings to individual pots of soil for further growth.

Ti (*Cordyline terminalia*). The ti is a native Hawaiian plant of considerable value ornamentally, and its leaves are used extensively as wrappers for fish and other foods. The plants are easily propagated from cuttings placed in almost any kind of soil or in fresh water. (Fig. 1, F.)

HEDGE PLANTS

Hedge plants, including such species as acalypha (*A. wilkesiana*) and several other related species, panax (*Nothopanax guilfoylei*), hibiscus (*H. species*), crotons (*Codiaeum variegatum*), barleria (*B. cristata*), plumbago (*P. auriculata*), and phyllanthus (*P. nivosus* var. *roseo-pictus*), are more or less ornamental, but are easily propagated in the ground where the hedge is desired. Cuttings, from 8 to 12 inches in length, of well matured shoots should be planted sloping to a depth of three-fourths their length in the ground. The soil should be tramped firm to hold them in place and to bring the soil particles into close contact with them. They should then be thoroughly watered and the soil around them should be kept damp at all times. Such hedge cuttings may be planted at any time of the year but the warm, moist conditions of early spring are generally considered best.

Other kinds of hedge plants are sometimes required where more protection is necessary. Thorny plants of algaroba, as grown from seed, and Natal plum, which is grown from both seeds and cuttings, may be propagated as previously described.

LITERATURE CITED

- (1) BAILEY, L. H.
1914. THE STANDARD CYCLOPEDIA OF HORTICULTURE. V. 2, p. 717-718.
New York and London.
- (2) COIT, J. E.
1919. CITRUS FRUITS. 520 p., illus. New York.
- (3) CORBETT, L. C.
1902. THE PROPAGATION OF PLANTS. U. S. Dept. Agr. Farmers' Bul.
157, 24 p., illus.
- (4) GOFF, E. S.
1918. THE PRINCIPLES OF PLANT CULTURE. Ed. 8, 295 p., illus. New
York.
- (5) GRIFFITHS, DAVID
1912. THE THORNLESS PRICKLY PEAR. U. S. Dept. Agr. Farmers' Bul.
483, 20 p., illus.
- (6) HUME, H. H.
1904. CITRUS FRUITS AND THEIR CULTURE. 597 p., illus. Florida.
- (7) MACMILLAN, H. F.
1925. TROPICAL GARDENING AND PLANTING. 594 p., illus. Ceylon.
- (8) MCCLELLAND, T. B.
1919. VANILLA: A PROMISING NEW CROP FOR PUERTO RICO. Puerto Rico
Agr. Expt. Sta. Bul. 26, 32 p., illus.
- (9) POPE, W. T.
1926. BANANA CULTURE IN HAWAII. Hawaii Agr. Expt. Sta. Bul. 55,
48 p., illus.
- (10) ————
1929. THE MACADAMIA NUT IN HAWAII. Hawaii Agr. Expt. Sta. Bul.
59, 23 p. illus.
- (11) ————
1930. PAPAYA CULTURE IN HAWAII. Hawaii Agr. Expt. Sta. Bul. 61,
40 p., illus.
- (12) ———— and STOREY, W. B.
1933. GRAFTING TROPICAL FRUIT TREES IN HAWAII. Hawaii Agr. Expt.
Sta. Circ. 6, 24 p., illus.
- (13) POPENOE, W.
1920. MANUAL OF TROPICAL AND SUBTROPICAL FRUITS. 474 p., illus.
- (14) WALTERS, E. A.
1932. PLANT PROPAGATION. Trop. Agr., V. 9, No. 2. Trinidad.
- (15) WESTER, P. J.
1924. THE FOOD PLANTS OF THE PHILIPPINES. Bureau of Agriculture,
Manila. 236 p., illus.

